



Economic losses due to Newcastle disease in layers in subtropical India

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ABSTRACT

Newcastle disease (ND) is a highly contagious viral disease of birds causing immense direct and indirect losses to the poultry industry. Various studies conducted across the world suggested that ND has been creating havoc in the poultry industry. Over the past decade, India has been reporting cases of ND outbreaks every year. Therefore, a retrospective study was conducted to estimate the losses due to ND and identify the factors influencing those losses. The primary data was obtained directly from farmers employing multistage purposive random sampling. A modified methodology was employed to provide an aggregate figure accounting for the approximate losses due to ND over the period of 72 weeks of the commercial layers' life cycle. The results of the study indicated that the losses due to morbidity were much higher compared to those due to mortality in ND-infected birds. The major factors influencing ND losses on the farms were drop in egg production, mortality of birds due to ND, duration of ND infection, reduction in feed intake, age at which birds get infected with ND, and experience of poultry farmers in the poultry business.

Keywords: Economic losses, Layer farms, Newcastle disease, Poultry diseases, Ranikhet disease

Newcastle Disease (ND) also called 'Ranikhet disease' or 'Avian pest' is a highly contagious viral disease of birds, caused by Avian avulavirus-1 of the family Paramyxoviridae. As per WOA (World Organization for Animal Health), ND is listed as one of the notifiable diseases having partial zoonotic significance, however, the disease is self-limiting in nature. As per the Annual Report of the Department of Animal Husbandry and Dairying (DAHD 2016-17, ...2020-21), amongst the major poultry diseases reported in India, ND accounted for about 21% of the total poultry disease outbreaks. The disease is known to infect all ages of birds, and the incubation period of the disease may vary from 2 days to 2 weeks. Based on the disease pathogenicity, Newcastle disease has been classified into three major pathotypes (Thyagarajan 2011) viz. Lentogenic, the most widespread and least pathogenic form of Newcastle Disease Virus (NDV); Mesogenic form of NDV have higher virulence compared to the lentogenic form and the mortality may go up to 50%; Velogenic, a highly virulent form of NDV, may cause mortality up to 100%. As per WOA guidelines, an outbreak of this form

is mandatory to be reported.

Various studies conducted across the world reported ND causing direct and indirect economic losses to the poultry industry (Khatun *et al.* 2018, Rehan *et al.* 2019, Kalaria *et al.* 2021). The direct losses due to ND comprised of losses due to the mortality of birds and drop in production, whereas indirect losses comprised of losses due to additional cost of treatment and control of disease, and the revenue forgone due to denied access to the market. Across India, various studies have been conducted that reported the endemicity of ND (Khorajia *et al.* 2018, Joshi *et al.* 2021, Kalaria *et al.* 2021). Despite it, very few efforts have been made to document the economic losses due to ND in the country. Therefore, a retrospective study was conducted to estimate the economic losses due to ND in commercial layer chicken and identify the factors influencing those losses. The study was directed to provide an aggregate figure accounting for the approximate losses due to ND over the period of 72 weeks of the commercial layers' life cycle.

MATERIALS AND METHODS

Sampling design and data collection: A total sample size of 90-layer farms was selected for data collection, employing a Multistage purposive random sampling method. The selection of the state and a district was done employing the Risk Index method (Bardhan *et al.* 2020) and the Indexing method (Chand and Sirohi 2012), respectively. The selection of villages and layer farms was

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carried out randomly.

The data obtained was directly from layer farmers through pretested interview schedule, for the period of April 2021 to March 2022. As the study was conducted in a retrospective manner, the identification and confirmation of ND-infected layer farms was based on the standard checklist of pathognomonic signs and symptoms of the disease, duly validated by experts. The data obtained was further classified and analysed using MS-excel and SPSS software.

Economic model: A modified method employed to estimate aggregate economic loss due to ND for a subtropical region in India was based on the cost and return analysis over the 72 weeks of the commercial life cycle of layers. For each ND-infected farm, data was obtained at two points in time viz. (a) at pre-ND infection status of the farm or healthy farm *vis-à-vis* ND, and (b) upon ND infection on the farm i.e., ND-infected farm (Fig. 1). The data obtained from the healthy farm *vis-à-vis* ND was analysed based on the assumption that the farm remained free from ND for 72 weeks, and while for the ND-infected farm, it was assumed that the farm was free from ND, then upon the occurrence of ND outbreak it became infected, and then again became ND-free upon recovery of birds (Supplementary Fig. 1).

The total economic loss due to ND was calculated as the summation of mortality loss (M_t) and morbidity loss (M_b) including the additional overall health expenditure. The total economic loss (TEL) was calculated as follows

$$TEL = M_t + M_b \dots (3)$$

The total cost (TC) component in cost and return analysis included chick cost (CC), feed cost (FC), labour cost (LC), electricity cost (EC), and overall health expenditure (OHE). The OHE parameter included the cost of vaccination (VC), and the cost of treatment and control (DSC). The total

returns (TR) on the farm were calculated as the summation of returns generated from the sale of eggs (EP), manure (MP), gunny bags (GP), and spent hens (SP).

The mortality losses were calculated as the difference in the total cost of rearing deceased birds and the returns generated from them till their mortality. The total mortality loss on all farms was calculated as follows (equation 4).

$$M_t = (EP + MP + GP) - (CC + FC + LC + EC + OHE) \dots (4)$$

$$M_t = TR - TC$$

The morbidity losses were calculated as the deviation in cost and returns on the ND-infected farm from that on the healthy farm *vis-à-vis* ND i.e., the difference in gross profit on ND-infected farms (G_{Mb}) and healthy farms *vis-à-vis* ND (G_H), equation 5. The gross profit was calculated as the difference in the total returns and the total cost, separately for both categories of layer farms over the period of 72 weeks. The morbidity loss for all farms was calculated as follows:

$$M_b = G_H - G_{Mb} \dots (5)$$

$$M_b = (TR_H - TC_H) - (TR_{Mb} - TC_{Mb})$$

where, TR_H , total returns generated on the healthy farm *vis-à-vis* ND; TR_{Mb} , total returns generated on ND-infected farm; TC_H , total cost incurred on healthy farm *vis-à-vis* ND; TC_{Mb} , total cost incurred on ND-infected farm.

RESULTS AND DISCUSSION

Out of the total sample size of 90-layer farms, 74 (~82%) farms were ND-infected indicating high prevalence of ND, while the rest (16 farms) were ND-free. All the birds on the ND-infected farms were considered infected with the disease because as per the guidelines of WOA, within the period of two to six days of virus entry, the whole

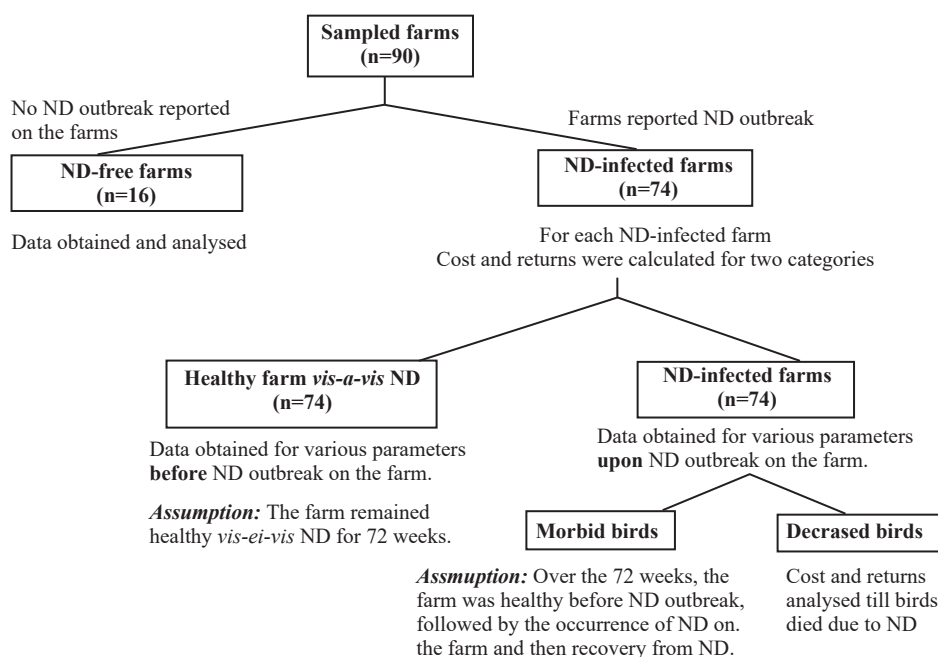


Fig. 1. Classification of sampled farms in the study area.

Table 2. Parameters accounted for estimating mortality losses due to ND (N = 11 Layer Farms)

Costs (₹/bird)			Returns (₹/bird)		
Parameters	Weighted Mean	SE	Parameters	Weighted Mean	SE
Chick cost (CC)	34.91	0.09	Eggs sold (EP)	383.88	53.75
Feed cost (FC)	499.77	52.59	Manure sold (MP)	4.03	61.50
Labour cost (LC)	14.39	1.17	Gunny bags sold (GP)	4.24	0.32
Electricity and water cost (EC)	10.22	0.03	Total revenue (TR)	392.15	0.33
Overall health expenditure (OHE)	10.22	0.03	Mortality loss/ bird deceased	173.28	13.00
Total cost (TC)	565.43	53.75			

flock become infected. Thus, the morbidity rate of ND in the study area was 83.3%, whereas the mortality rate was only 3.25%. Most of the parameters employed in the computation of economic losses were obtained from the field survey except for the price of egg sold and the price per kilogram (kg) of spent hen sold i.e., the figures were taken from the secondary sources in order to eliminate variations introduced due to price fluctuations in estimating ND losses across all the farms (Supplementary Table 1).

As a consequence of the ND outbreak, the reduction in egg production was recorded up to ~29 % per farm. The duration of ND on layer farms till their recovery and restoration of egg production to the pre-infection level was ~9 weeks. The reduction in feed consumption was recorded at up to 18 % per farm, which resulted in savings made in the feed cost. The reduction in feed consumption was also reported in a study conducted on village chickens infected with ND (Khorajia *et al.* 2015).

Estimation of mortality losses: The mortality of birds due to ND was reported only on the 11-layer farms ranging from 5-50%. The mortality loss calculated on 11 ND-infected farms was ₹ 173.3 per deceased bird (Table 2).

Estimation of morbidity losses: The morbidity losses were calculated for the birds left after excluding the number of birds that died due to ND in ND-infected farms. A significant decrease in feed consumption was observed in ND-infected farms, in addition to an increase in overall

health expenditure (OHE) and a decrease in egg production compared to those on healthy farms *vis-à-vis* ND. The total cost incurred, and the total revenue generated was significantly different on ND-infected farms compared to healthy farm *vis-à-vis* ND (Table 3). Therefore, the morbidity loss reported on 74 ND-infected farms was ₹ 55.67 per bird over the period of 72 weeks.

Total economic losses due to ND: Overall, the total economic loss estimated on 74 ND-infected farms was ₹ 58.71 per bird and ₹ 4.74 million on a per-farm basis. The morbidity losses accounted for 90% of total economic loss while the rest accounted for mortality losses (Table 4). The results of the present study were in corroboration with the study conducted in Gujarat in broilers by Kalaria *et al.* (2021) i.e., economic loss due to ND was ~ ₹ 55 per bird. Whereas the results of the study conducted on Genotype-XIII ND virus did not corroborate with the present study as the total economic loss due to ND was ₹ 24 per bird (Khorajia *et al.* 2018).

Based on the results of the study, the total economic losses due to ND for the subtropical region in India can be estimated. For example, the ND losses were worked out for Haryana state as the product of the prevalence rate of ND and the total commercial layer population of the region multiplied by the economic loss due to ND on per bird basis, given as follows:

Table 3. Comparison of various economic parameters on healthy and ND-infected layer farms

Parameter	n=74				T _{cal}	p value
	Healthy farm <i>vis-à-vis</i> ND (₹/bird)		ND-infected farm ^s (₹/bird)			
	Mean	SE	Mean	SE		
Chick cost (CC)	34.96 ^a	0.05	34.96 ^a	0.05	-	-
Feed cost (FC)	1179.25	5.78	1145.65	6.67	18.05	<0.001
Labour cost (LC)	28.12 ^a	0.43	28.12 ^a	0.43	-	-
Electricity and water cost (EC)	5.96 ^a	0.94	5.96 ^a	0.94	-	-
Overall health expenditure (OHE)	10.59	0.01	10.62	0.02	23.77	<0.001
Total cost (TC)	1258.90	5.82	1225.33	6.69	18.04	<0.001
Eggs sold (EP)	1266.58	8.73	1177.32	8.07	18.95	<0.001
Manure sold (MP)	8.25 ^a	0.09	8.25 ^a	0.09	-	-
Gunny bags sold (GP)	8.67 ^a	0.08	8.67 ^a	0.08	-	-
Spent hen sold (SP)	68.30 ^a	0.23	68.30 ^a	0.23	-	-
Total revenue (TR)	1351.84	8.72	1262.57	8.06	18.95	<0.001
Gross profits (G = TR-TC)	92.94	10.82	37.24	9.57	18.15	<0.001

^a Denoted non-significant difference within the row. ^s Denoted parameters for ND-infected birds left after excluding deceased birds

Table 4. Economic losses using the modified method

Particular	Mortality loss (₹)	Morbidity loss (₹)	Total economic loss (₹)
Loss/ farm ^s	0.56 million	4.18 million	4.74 million
Loss/ bird [#]	6.03	52.68	58.71
Percentage	10.27	89.73	100

n, number of poultry farms; ^stotal loss divided by total no. of ND-infected farms, i.e., 74; [#]total loss divided by total no. of birds initiated on 74 ND-infected farms (without excluding deceased birds).

Total economic loss due to ND (Haryana) =
Prevalence rate × Total commercial layer population of
the state × Per bird economic loss due to ND

According to the BAHS-2021 report, the total commercial layer population of Haryana was 279,82,180 birds. Based on the prevalence rate of ND in the Haryana region, the alternative scenario analysis was conducted to estimate the total economic loss due to ND in commercial layers, incurred by the state (Table 5).

Table 5. Alternate scenario analysis: Projected economic losses due to ND in Haryana state in commercial layers

Prevalence rate of ND	9.8*	50.0**	83.3***
Economic loss due to ND by the modified method (₹)	160.99 million	821.42 million	1,368.48 million

*prevalence rate of ND as estimated in the backyard and commercial poultry in Haryana (Joshi *et al.* 2021). **Assumed prevalence rate for alternate scenario analysis. ***Prevalence rate of ND as estimated in the present study.

Factors influencing the economic losses due to ND: The multiple regression model was employed for the identification of factors influencing losses due to ND. The dependent variable considered for the analysis was the estimated total economic loss due to ND. The explanatory variables considered in the model were given as follows:

X₁, flock/ farm size (small=1, medium=2, large=3); X₂, ND vaccination (ill-vaccinated=1; otherwise=0); X₃, education qualification of farmer (secondary education=1, otherwise=0); X₄, experience in poultry farming (number of years); X₅, knowledge of ND (No knowledge= 1, Partial knowledge=2, complete knowledge=3); X₆, number of birds died due to ND (number); X₇, season of ND occurrence (Winter=1, Rainy=2, Summer=3); X₈, reduction in feed intake (g/day); X₉, increase in overall health expenditure (₹); X₁₀, inter-farm proximity (number of farms in 1 km proximity); X₁₁, biosecurity (good=1, otherwise=0); X₁₂, age of birds at which ND occurred (wks.); X₁₃, duration of ND till recovery (wks.); X₁₄, drop in egg production (number).

The regression results indicated that the explanatory variables, namely, age of birds at which ND occurred, reduced feed intake in morbid birds, and experience of poultry farmer had significant negative impact on the economic losses due to ND, whereas variables namely, mortality of birds due to ND, duration of ND infection and

drop in egg production had significant positive impact on ND losses (Supplementary Table 6). The rest of the factors considered for regression were found to have no influence on ND losses.

The results of the study were not in corroboration with the results of the study conducted in layer farms of Tamil Nadu, which reported the farm size, and health expenditure per bird had significant positive impact on ND losses, whereas inter-farm proximity had a significant negative impact on ND losses (Selvam *et al.* 2004).

To conclude, the Newcastle Disease proved to have serious implications on the profitability of the layer farms. The methodology employed in the study can be used to estimate total economic loss due to ND for a particular region based on the prevalence rate of the disease in that region. The morbidity losses accounted for the lion's share in total economic losses due to ND, primarily due to decrease in egg production, therefore, poultry farmers have been advised to cull their infected and unproductive birds as soon as possible. The factors having bearing on economic losses due to ND by and large were associated with the occurrence of ND in poultry farms. Hence, the best course of action to minimise these losses would be to prevent ND infection as far as possible. Also, there is a need to educate farmers about the disease and its prevention and control like practising stringent biosecurity measures on their farms.

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